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To M. C. Leverett

Subject SOME NOTES REGARDING THE PROPOSED MOVE OF CLINTON LABORATORIES TO Y-12

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SOME NOTES REGARDING THE PROPOSED MOVE OF CLINTON LABORATORIES TO Y-12

RHTG # 108926
BOX # 235

I would like to make a few more comments concerning the proposed move of Clinton Laboratories to the Y-12 area as follows:

1. If the new piles are to be located in the area of the present Y-12 alpha buildings, we should consider the distance to the Oak Ridge permanently populated area as 2 miles instead of 3.

2. Your method of multiplying the permissible tolerance concentrations of radioisotopes in air for one year exposure by the hours in a year (8760 hr) to get the permissible exposure for one hour is a safe assumption for the relatively long lived radioisotopes. The radiation rate in such cases is given by the equation:

$$Z = 876 \frac{1 - e^{-.693/8760\ Ty}}{1 - e^{-.693/Ty}}$$

Under these conditions a radioisotope like Sr^{89} with an effective half-life (λ effective = λ biological + λ physical) of 43 days would produce a radiation rate after an hour's exposure of 0.527 r/day. Under these conditions a person living in Oak Ridge would receive above tolerance exposure to the bone (> 0.1 r/day) for 103 days after the hour's exposure and an exposure less than tolerance for the rest of the year, but the total year's exposure would be only 36.5 r. This is just about the maximum exposure we could permit because experiments from Dr. A. H. Dowdy's laboratory have indicated that undesirable biological changes take place when an animal is exposed for several months to doses in excess of 0.5 r/day. I would consider such a dose as the limiting permissible emergency dose.

In the case of a shorter lived element like I^{131} with an effective half life of 6.3 days, the initial radiation rate is 40.1 r/day to the thyroid. In this case the exposure to the thyroid is above tolerance for 34 days (the tolerance level to the thyroid is considered as 1.0 r/d instead of 0.1 r/d) and less than tolerance the rest of the year. The year's dose, however, is only 365 r. This again I consider as about the limiting safe emergency dose.

In the case of an isotope with an effective half-life of one hour (I^{134} has a half-life of 54 minutes), the initial radiation rate is 438 r/day. However, this high rate is received for only a few hours and drops to tolerance or 0.1 r/day after 12.1 hrs. so that the thyroid gets a good treatment dose of about 365 r in a single day. This would bring about some undesirable changes in a normal thyroid, perhaps, but it is not considered to produce any serious or permanent damage to most individuals. It might lead to cancer in tissue adjacent to the thyroid in a very small number of individuals (probably $< 1/10^3$) in cases where $dr/dt \rightarrow \infty$ even though the total dose was < 365 r. This again would be considered a limiting emergency dose.

3. I do not believe it permissible to determine the total curies of iodine by the method

$$4 \times 10^7 \times 3.1 \times 10^{10}/3.7 \times 10^{10} \times 0.19 = .66 \times 10^7 \text{ curies of iodine}$$

as was done in the report of the Pile Hazards Committee, 1/9/47. For one thing

1. Classification Retained
2. Classification Changed To:
3. Contains No DOE Classified Information
4. Coordinate With:
5. Classification Cancelled
6. Classified Information Bracketed
7. Other (Specify):

Authority: ☐ ADC ☒ ADD
Name: [illegible] ORO
2nd Review Date 4-8-96
Authority: ADD
Name: [illegible]

the 1% used above is the number of iodine atoms produced per 100 fissions of U^{235} and is not the percent curies present over Oak Ridge.

4. The method of determining the necessary dilution from equation

$$Qa = \frac{2.09 \times 10^{-6}}{E}$$ $\mu c/cc$ of air, in which Qa is the permissible

concentration to give a tolerance rate of 4.17 mr/hr to a body submerged in a radioactive gas or cloud of radioactive dust seems to be reasonable. For an average energy, $E_{av} = 0.2$, this leads to a necessary dilution factor of 3.4×10^7 times to receive a fatal dose of 400 r total body radiation in one hour if the initial quantity emitted is 3.3×10^7 curies from the explosion. There is no question but that such a level of radiation exposure would do serious damage or kill many people (perhaps thousands) in Oak Ridge in one hour's exposure. I would recommend using 1/10 of this exposure or 40 r/day as the maximum permissible total body emergency exposure. This would cause considerable biological changes in man, but is not calculated to kill anyone (for example, it is probable that 50 r in a single total body dose will induce ovarian tumors in women). It is about the order of magnitude of the maximum permissible dose allowable for catastrophe circumstances (as I recall) that was quoted by Dr. R. S. Stone. Such a dose might cause serious complications to a certain fraction of persons so exposed and probably should be further reduced by a factor of two in order to protect the women.

5. Experience has indicated that the average half-life of U^{235} fission radioisotopes one hour after production is about one hour. I have found that the equation

$$T = \frac{6 \times 10^4}{E_o^{6.4}}$$

gives the best relation between maximum energy of beta fission products and half-life ($T \equiv$ seconds and $E_o \equiv$ Mev). If then $T = 60$ sec, we find that $E_o = 2.95$ Mev. The average energy ($= 1/3$ max.), therefore, is about 1 Mev instead of 0.2 Mev as used in the previous problem. Therefore, the dilution factor required for the average beta emitting radioisotopes is $5 \times 10 \times 3.4 \times 10^7 = 1.7 \times 10^9$ times to permit 40 r exposure.

6. Probably the most pessimistic assumption we can make is that the total radioactivity in the air after a power pile explosion at the Y-12 site at the time the cloud arrives at the city limits of Oak Ridge is 3.3×10^7 curies. Using the "1/7 law", the diameter of the cloud at 2 miles is 460 meters and the volume is 5.1×10^7 m^3 or the dilution factor is 5.1×10^7 if the initial volume is one m^3. The concentration is then

$$3.3 \times 10^7 \times 10^3 / 5.1 \times 10^7 \doteq 650 \text{ mc/m}^3 \text{ or } 0.65\ \mu c/cc.$$

This is 33 times the dose of 40 r/day or the air must be diluted 33 more times if a person two miles away is to receive only 40 r total body radiation in an hour's exposure.

7. If we take the general internal tolerance level for a general mixture of fission products ($= 10^{-7}\ \mu c/cc$) and multiply it by the hours in a year (8760 hrs/yr), we obtain 8.76×10^{-4} $\mu c/cc$ as the maximum permissible emergency

concentration for one hour's consumption. The concentration at the city limits under the above assumptions was 0.65 μc/cc or 743 times the permissible value for inhalation of mixed fission products for one hour.

8. Let us assume that 20 gm Pu are vaporized into the air by the explosion. This would mean a concentration of $20 \times 10^6 / 5.1 \times 10^7 = .39\ \mu gm/m = 3.9 \times 10^{-7}\ \mu gm/cc$. The tolerance value for plutonium consumption is calculated (in my report "Tolerance Concentrations of Radioactive Substances") as $2 \times 10^{-9}\ \mu gm/cc$. If again we multiply this by the hours in a year, we have $2 \times 8760 \times 10^{-9} = 1.75 \times 10^{-5}\ \mu gm$ Pu/cc of air as the maximum permissible emergency concentration. It seems then that plutonium, U^{234} and other alpha emitters would present no serious hazard to Oak Ridge.

9. The conclusion is that many people ($\gtrsim 1000$) would be killed or seriously injured in Oak Ridge if 3.3×10^7 curies of fission products were released into the air over Oak Ridge. The initial quantity of radioactive fission products given off over Oak Ridge should not exceed 10^6 curies for an exposure of one hour if the total body exposure is to be limited to 40 roentgens. Since even this exposure might cause an increased incidence of ovarian tumors, it is believed best to set the limit at 5×10^5 or 10^5 curies. This would add a factor of safety to take care of combination radiation damage effects. It is believed that the probability of this radioactive cloud containing $\geq 10^5$ curies by the time it passed over Oak Ridge as otherwise assumed above is very slight (probably $< 10^{-3}$ of the explosives would send $> 10^5$ curies over Oak Ridge). Therefore, the risk seems to be a reasonable one, when we consider the small probability of an explosion in the first place, and the hazard is probably no greater than that frequently assumed in other industries. This hazard differs from others only because of its uniqueness and because of the insidiousness of radiation.

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